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REVIEW ARTICLE

Exenterative Pelvic Surgery

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A review of the history, indications, basic technique, end results, and complications of exenterative surgery for pelvic neoplasms is provided. The authors discuss their broad personal experience with the operation. Much of this experience evolved from work at Barnes Hospital and the Ellis Fischel State Cancer Hospital. The techniques are applicable to advanced neoplasms of the cervix uteri, scrotum, urinary bladder, and other, less frequent neoplasms still confined to the pelvis.
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INTRODUCTION

Pelvic exenteration involves the en bloc resection of portions or all of the rectum, distal colon, bladder, and lower segments of the ureter; all internal reproductive organs; portions of the perineum; the draining pelvic lymph nodes; and the pelvic peritoneum. This operation has evolved since its description in the 1940s and is today an established procedure for the treatment of patients with locally advanced pelvic malignancy. Although the operation has been used as a salvage procedure after radiation treatment of various pelvic tumors, it can also be used in the setting of primary, untreated, locally advanced tumors invading the lumen of the rectum, bladder, and vagina for which no other local therapy can reduce the magnitude of the operation. Although the mortality from pelvic exenteration has significantly declined as experience has been gained, it remains a morbid operation in both the short and long terms. Proper case selection based on important patient and tumor factors is essential to obtain good results with this procedure. It is the purpose of this article to review factors that make the operation feasible and appropriate, technical considerations of importance to the practicing surgeon, and the results that can be expected after exenterative pelvic surgery.

HISTORICAL NOTES

Pelvic exenteration was developed relatively late in the evolution of radical oncologic surgery. In the mid-1940s, radical total cystectomy, abdominoperineal resection of the rectosigmoid, and radical hysterectomy were established operations, but the morbidity of combining these procedures was prohibitive. Influenced by advances in other types of radical cancer surgery and in perioperative care, the operation was developed simultaneously at several centers in North America but was first reported by Brunschwig in 1948 [1–5]. Brunschwig, a general surgeon, was chairman of the Gynecologic Service at Memorial Hospital in New York when he reported on the results of pelvic exenteration in the treatment of advanced carcinoma of the cervix. For Brunschwig, it was the broadening of his philosophy of surgical treatment of cancer of the cervix, including patients whose cancers previously were considered incurable or inoperable. Appleby independently applied the same concept to advanced carcinoma of the rectum in 8 male patients by an operation he reported in 1950 as "proctocystectomy" [2]. Also independently, Brintnall and Flocks [3], in 1950, reported on "pelvic viscerectomy" in 9 cases of carcinoma of the rectum. Both Brunschwig and Appleby had substituted for the urinary bladder by diverting the urinary stream to the colon proximal to the colostomy, providing the so-called wet colostomy. In 6 cases re-

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ported by Brintnall and Flocks, the right ureter was transplanted to the cecum and the left to the sigmoid colon.

In 1940, Bricker became the first surgeon-in-chief at the newly constructed Ellis Fischel State Cancer Hospital (EFSCH) in Columbia, Missouri. On 8 August 1940, Bricker performed the first total pelvic exenteration at this new hospital. His interest in radical pelvic surgery and the poor results that had been obtained with urinary diversion into the wet colostomy led him to develop the ileal conduit [6]. The Bricker procedure remains the standard against which all other methods of urinary diversion are evaluated. Subsequent efforts at the EFSCH and at Barnes Hospital in St. Louis, Missouri, resulted in a remarkable combined cumulative experience with radical pelvic surgery, which at one time was probably the largest experience in the world. Continued interest in this subject led to the first comprehensive publication of exenterative surgery of the pelvis by Spratt et al. in 1973 [7]. Subsequently, those of us who were privileged to work for Drs. Bricker and Spratt were inspired and stimulated to contribute to the development of total pelvic exenteration as a safe and appropriate option for patients with cancer incurable by other means [8–16]. More recently, a 50-year institutional experience with this operation has been reported by our group [17].

Thus, in the past 50 years, exenterative pelvic surgery has passed through a maturing process that today places it in a unique position. It is still a formidable technical procedure with unavoidable functional consequences, but fortunately it is required less frequently because early diagnosis and primary treatment of carcinoma have improved. This is particularly true with the "down-staging" effect of chemoradiation for certain pelvic neoplasms.

Down-staging is a result of the death of several logs of cancer cells, resulting in mass reduction only. There is no evidence that the molecular genetics of the remaining cancer is altered. Also, advanced cancers with low rates of proliferation are less likely to undergo a reduction in mass with chemotherapy or irradiation. Often, the same operation is required after chemoradiation as would have been initially required, and the effect on survival remains unresolved for many advanced pelvic cancers and cancers with adverse pathological and molecular genetic characteristics. In some instances, lesser operations have been possible.

The anatomic and pathologic bases of the operation for several pelvic cancers remain sound. Experience has resulted in decreased operative mortality and greater selectivity of patients for the procedure. Currently, operations are more frequently tailored to fit individual lesions, being aimed chiefly at preservation of function, and are performed only when the chance for cure will not be jeopardized. The uniqueness is further emphasized by the multiorgan involvement creating specialty overlap that has developed in this anatomically crowded area, where technical ability and experienced judgment are required for an operation that is done with relative infrequency. Bricker et al. [18] pointed out that all of these factors emphasize the continued need for referral of candidates for extended radical pelvic operations to centers where surgeons have a special interest in the problem and where experience can be cumulative. Furthermore, essential to maintaining the low morbidity and mortality with this operation are indispensable ancillary services necessary to support the surgical effort, including experienced anesthetists, adequate blood banking facilities, skilled postoperative nursing care, intensive care unit, trained enterostomal therapists, and the availability of adequate psychosocial support as necessary. A successful outcome will depend largely on the team effort in addition to a working rapport with the patient and family.

This subject cannot be covered completely without reference to the role of multimodality therapy for advanced pelvic malignancy. Contemporary oncological surgery often requires multispecialty consultation and treatment. In most cases of advanced pelvic malignancy, surgery of this magnitude must be considered the last resort. However, the team must bear the responsibility of avoiding an operation that has proven curative in a substantial number of patients with locally advanced pelvic malignancy. Often, the final decision rests with the surgeon with the most experience with exenterative surgery and on the patient's informed consent. Bricker et al. [18] summarized the early developments and results of pelvic exenteration, the second such comprehensive review of the subject in the surgical literature.

INDICATIONS AND PATIENT SELECTION FOR EXENTERATIVE PELVIC SURGERY

The success of pelvic exenteration is highly dependent on good patient selection and understanding the biological features of pelvic cancers, where an en bloc resection may result in prolonged disease-free survival and long-term cure. In selecting patients for pelvic exenteration, it is essential that all factors be considered in the context of how great the impact of this operation will be on the physical and mental health of the patient, quality of life, and probabilities of freedom from disease. Although pelvic exenteration was devised primarily as a palliative operation in a desperate attempt to relieve young women from the ravages of locally advanced cancer of the cervix, we have advocated its use for many years exclusively for the cure of patients with advanced pelvic malignancies [7,8,12–18]. More recently, as the morbidity and mortality of this operation have decreased, the indications have become more liberal, and palliative exenteration has its advocates [19]. Thus, in considering curative or palliative exenterative pelvic surgery, it is critical to define the settings in which this operation can be justified. In this review, patient- and tumor-related fac-

tors are presented independently for the purpose of clarity, although they are intimately related.

Chronological age offers no barrier beyond which a patient categorically should not be considered a candidate for pelvic exenteration. The physiologic age is much more important and is a determinant of organ function and mental status, both of which strongly influence patient selection [18]. Patients in their seventh decade of life, who are otherwise in good health, are good candidates for this procedure. Patients older than 70 years should be approached with great caution, although it is not unusual for older patients to be subjected to exenterative pelvic surgery with success. Nevertheless, as with all other types of major surgery, the operative risk and mortality increase with age. Older patients who are obese and those with limited mobility, hypertension, or clinical evidence of significant organ dysfunction are generally not suitable candidates for this procedure. Antecedent history of thromboembolism, poorly controlled diabetes mellitus, and pre-existing pelvic sepsis, fistulas, or complications associated with radiation therapy increases the morbidity of this operation substantially. Although none of these factors are strict contraindications to pelvic exenteration, the multiplicity of these factors makes preoperative patient selection more difficult. Symptoms indicative of inoperability include leg edema, back or flank pain due to ureteral obstruction, pelvic bone pain secondary to invasion of the side wall, and sacral plexus.

The surgeon must have repeated discussions with the patient, spouse, and close relatives to be sure that all understand the implications of the proposed operation. The patient in particular must understand its significance and have the desire to get well. A negative attitude and intelligence inadequate for self-care after the operation are contraindications to this procedure. Physical inability to ambulate and excessive dependency on relatives for personal care also are, with rare exceptions, contraindications to the operation. The sexual incapacitation that will result after the operation must be well understood by the patient and spouse. For younger patients in whom this may be a very important factor, the possibility of subsequent reconstruction should be included in the discussion and planning. The interaction among the patient, family, supportive surgical nursing staff, enterostomal therapist, social worker, and psychological support are of utmost importance at this stage of the preoperative evaluation process.

The search for evidence of spread of the cancer beyond the true pelvis must be comprehensive. Exact clinical staging of the intrapelvic lesion can be accurately determined at operation. The presence of extrapelvic metastases establishes a lesion as being incurable by surgical means. The preoperative assessment should begin with a complete physical examination. All palpable lymph nodal areas should be examined carefully, with particular attention paid to the supraclavicular and inguinal areas. Any palpable nodes suspicious for metastases should be subjected to fine-needle aspiration cytology or excision for cytologic or histologic assessment, respectively. All patients being evaluated for pelvic exenteration should undergo computed tomography (CT) of the chest, abdomen, and pelvis because multiple extrapelvic solid organ metastases are clearly a contraindication to pelvic exenteration. Rare exceptions to this rule are patients with a solitary pulmonary or hepatic metastasis that, if deemed resectable, can be attended to after the patient has recovered from exenterative pelvic surgery. In-transit metastases at extrapelvic sites of nodal disease (e.g., periaortic or hilar hepatic lymph nodes) would have to be excluded first. As with carcinoma of the colon and rectum, there is evidence that metastasectomies of pulmonary or hepatic lesions may prolong the disease-free survival [20,21].

Due to the wide variety of malignant neoplasms that arise in the pelvis, an appreciation of their biological behaviors is paramount to proper patient selection for exenteration. Several primary neoplasms, specifically prostatic and ovarian carcinoma, are by the nature of their frequent extrapelvic spread unsuitable tumors for eradication by means of exenterative pelvic surgery. Of similar behavior, although occasionally indolent, is endometrial carcinoma. Because the sine qua non for pelvic exenteration is invasion through the primary organ into contiguous viscera, the majority of patients with endometrial carcinoma and extrauterine extension have periaortic or peritoneal metastases. Table I presents an estimate of the frequency with which pelvic exenteration is done for various cancers arising in the pelvis [18]. Although this is an estimate based on the experience of several researchers, it is notable that the prevalence of locally advanced carcinoma of the cervix has decreased by >50% since the 1940s. The decline is presumed to be a result of cervical cytologic screening. In addition, the stage at diagnosis of cervical cancer has shifted, and >50% of patients currently have early-stage disease.

In addition, advances in radiation therapy, especially brachytherapy, have improved survival in some patients with advanced disease, thereby reducing the number of treatment failures and thus the need for exenterative pelvic surgery. Therefore, it may well be that the current proportion of pelvic exenterations performed for recurrent or primary locally advanced rectal cancer has increased in relation to the overall patient population treated by pelvic exenteration. Current multimodal treatment of rectal cancers, especially with the use of preoperative chemoradiation, produces a down-staging effect. It is unknown, however, whether radiotherapy can downstage a tumor resectable only by pelvic exenteration into one resectable with negative margins by abdominoperineal resection or some other operation of lesser magni-

TABLE I. Cancerous Lesions Treated by Pelvic Exenteration*

	% Frequency
Considered biologically favorable	
Cervix—recurrent after irradiation	75
Rectum or sigmoid—primary treatment	10
Cervix—exenteration as primary treatment	3
Uterus—endometrium—persistent or recurrent	3
Vagina—primary or recurrent	2
Adenocarcinoma of cervix—primary or recurrent	2
Vulva—squamous cell carcinoma—primary treatment	2
Anus—squamous cell carcinoma—recurrent treatment	1
Palliative operation for carcinoma of cervix	1
Postirradiation fibrosis, necrosis, or fistula	1
Considered biologically unfavorable	
Ovary	
Urinary bladder or urethra	
Prostate—adenocarcinoma	
Prostate—sarcoma	
Uterus—sarcoma	
Melanoma—anus, vulva, or vagina	
Rhabdomyosarcoma	

*The table presents an estimate based on the experience of several researchers. The implication is that the lesions are advanced and require extended surgery for management, although some of those included may require only a modified exenteration. Those listed as biologically unfavorable were treated by exenteration under certain circumstances, and a few are long-term survivors. Reproduced with permission from Williams and Wilkins, Bricker et al. [18].

tude [16,22,23]. Also, the reduction in mass with downstaging does not change the biological properties of the cells composing the cancer. These biological properties often are a more significant determinant of outcome than the anatomical stage.

The biological behavior of colorectal cancer has been the subject of intense study since the early part of the 20th century. In the 1960s, a "nonmetastasizing" variant of colorectal cancer was beginning to be clearly defined [24,25]. Although some colorectal cancers penetrate through the intestinal wall and attain large size, these tumors may remain localized for protracted periods without spreading to regional lymph nodes and may be curable by definitive en bloc resection. The biological behavior is unlike that of most other epithelial tumors, in which locoregional invasion usually is associated with regional or distant metastases, as is particularly true of other gastrointestinal adenocarcinomas. Favorable colorectal cancers can be identified on histologic examination. They are well differentiated, have pushing or well circumscribed rather than infiltrating margins, and are surrounded by a distinct inflammatory cellular response. Venous, lymphatic, or perineural invasion is usually absent. In a 1967 multivariate analysis of >1,000 consecutive colorectal carcinomas resected at the EFSCH, two-thirds of the largest carcinomas resected (some >13 cm in diameter) had not metastasized to regional lymph nodes [25]. In a more recent paper from the same institution, carcinomatous invasion of the resected contiguous organs from colorectal cancer was confirmed in 84% of 58 patients undergoing multivisceral resections, and 81% of these patients had no metastases in the regional lymph nodes [26].

In addition to these clinical pathologic observations, a recent multivariate analysis using DNA flow cytometry data as a prognostic marker was applied in 40 patients undergoing pelvic exenteration for rectal adenocarcinoma. An S-phase fraction of $\geq$10% indicated a poor survival. These investigators developed a prognostic index that identified a low-risk group with a 5-year survival rate of 65% and a high-risk group with a 5-year survival rate of 20% ($P < 0.005$) [27]. Other investigations are using the tumor suppressor gene p53 as a preoperative prognostic indicator for locally advanced rectal cancer, and the preliminary results appear promising. Spratt and Meyer [28] recently reviewed the biological considerations with pelvic neoplasms.

Stern [29] reviewed the rapid growth of insight into the correlation between molecular genetics and the clinical behavior of colon cancer. Predictably, molecular genetic characteristics of colon cancers correlate easily with clinical behavior and prognosis known from prior studies. For example, Yamamura et al. [30] reported that p53 overexpression is an excellent prognosticator of hematogenic recurrence of colorectal cancers, knowing from past clinical observation that the probability of metastases from colorectal carcinomas is independent of the size of the cancers [24,25]. The ability may soon be at hand to identify, on the basis of their molecular genetic properties, cancers that will metastasize. This could then be the major target group for systemic adjuvant therapy trials.

Contrast-enhanced CT, the mainstay of abdominopelvic imaging, is reasonably sensitive in determining the probable regional extent of the cancer, particularly at the level of the perirectal pelvic fascia. However, early transmural bowel extension cannot be accurately predicted by CT [31]. There is evidence that CT overstages tumors and that it understages as many as 23% of tumors [32]. Transrectal ultrasonography is the state-of-the-art imaging technique in rectal cancer. The correlation between endoluminal ultrasonography and histologic depth of transrectal invasion is about 90%, and 60–80% of perirectal lymph node metastases can be identified [33–35]. Transrectal magnetic resonance imaging is a promising tool currently under investigation. Radiolabeled monoclonal antibodies may have a future role in staging [36]. However, none of these imaging techniques can accurately differentiate between inflammatory and neoplastic adhesions between viscera [16].

Conducting a pelvic examination with the patient un-

der anesthesia is useful to assess tumor extent or fixation; cystoscopy and proctoscopy are key elements of such evaluation [18]. Biopsy specimens can be obtained at this time. Consultation with potentially necessary disciplines may be useful in the operating room, with the radiotherapist taking part in these evaluations. The importance of bimanual pelvic examination cannot be overemphasized. Fixation to musculoskeletal pelvic can be assessed. It can provide a reliable measure of the likelihood of complete resection. In addition, with extrarectal extension, as determined by digital examination, preoperative radiation therapy may be considered [14]. To date, clinical staging systems for locally advanced rectal cancer remain essentially subjective and are, therefore, highly dependent on the expertise of the examiner. As noted earlier, endorectal ultrasound is very reliable in the staging of early rectal cancer, including determination of tumor extension into the perirectal fat; however, tumor fixation to adjacent prostate and bladder in males and to uterus and vagina in females can be best ascertained by manual examination in the operating room with the patient under anesthesia. The feasibility of preserving lower portions of the anorectum or genitourinary tract can also be ascertained during this examination [7,18].

THE OPERATION

The performance of pelvic exenteration requires indepth knowledge of the contiguous anatomy of the parietal and visceral pelvis. Various combinations of operations may be necessary because of the extent of specific neoplasms. Surgical technique is always compromised if anatomic knowledge and insight are deficient. Therefore, a surgeon who would perform exenterative pelvic surgery must first be a good anatomist [37]. The technical descriptions of surgical techniques in this review are intended for communication among experienced surgeons because they presume a basic knowledge of anatomy and methods of dissection. The operation has also been presented in detail elsewhere [7,38].

The anatomy of the pelvis must be viewed in a nonorganocentric manner by a surgeon performing a pelvic exenteration. This means that the removal of various organs within the enveloping fascia is the secondary objective of the operation. The primary objective is the en bloc removal of cancer that has extended beyond the organ of origin. In this regard, exenterative surgery of the pelvis has many characteristics in common with other cancer treatments requiring extensive dissection. For these reasons and because the operation must be, at times, executed with a great deal of improvisation, only surgeons with advanced oncologic training or close preceptorial supervision should perform a total pelvic exenteration.

After extensive research of the anatomic and surgical literature for studies most relevant to the requirements of exenterative surgery, none exists superior to that of Uhlenhueth, published in 1953 [39].

Uhlenhueth, professor of anatomy at the University of Maryland, in discussion with the urologist who was attending his wife with bladder cancer realized that the urologist had inadequate knowledge of pelvic anatomy. He redirected his departmental research toward detailed dissections of the pelvis, emphasizing fascial anatomy as few had done before. One of us (J.S.S.) went to Maryland to view these remarkable dissections. The knowledge acquired was of great value in refining the surgical technique for both ilioinguinal lymph node dissections and pelvic exenteration [7,40].

In the text on exenterative surgery [40], key illustrations from Uhlenhueth's out-of-print text were duplicated, and surgical dissection was described with respect to the fascial plains. If fascial plain dissection is followed, a better resection is obtained, and blood loss is minimized. In this text only, several carefully selected drawings display the fascial anatomy, and more reliance is placed on illustrations of actual surgical technique.

The operative setting for pelvic exenteration does not differ from that of other major abdominal and pelvic operations. However, especially long instruments to reach the deep portions of the pelvis and deep retractors are essential [7]. With the patient supine, the hips are fully flexed in the dorsal lithotomy position, with the knees flexed in leg holders. Although this position is preferred by one of us (M.J.L.), the ski position is also acceptable. The ski position does not provide as good posterior perineal exposure when extensive posterior dissection is required. The lower extremities of the patient rest on a well padded plantar surface rather than on the heel or popliteal area. Pressure necrosis of the skin and venous stasis can easily occur during this lengthy operation. Intermittent venous compression devices or graded elastic stockings and subcutaneous prophylactic heparin may be used. The patient must be positioned so that the tip of the coccyx extends beyond the end of the folded table, and the sacrum must be well padded to prevent pressure necrosis and to promote exposure of the posterior perineum and the coccyx. If a sacral resection or hemipelvectomy in association with a total pelvic exenteration is anticipated, a change to a lateral decubitus or prone position will be necessary after the abdominal and perineal portions are completed. Both the rectum and bladder are catheterized, and the rectum is irrigated with half-strength povidone–iodine solution. The rectal catheter also is connected to a closed drainage system to keep the rectum empty. For tumors extending into the external genitalia, particularly in women, obliteration of the vulva is accomplished by continuous suture from just above the clitoris to the postanal region. One of us (J.S.S.) prefers to lightly pack the vagina with a gauze roll saturated with povidone–iodine. If the tumor is exposed on the external

genitalia, it is covered with laparotomy gauze saturated with povidone–iodine. The gauze is held in place with wide-stay sutures. For patients with tumors of the middle or high pelvis, the external genitalia can be preserved for closure or reconstruction.

Intraoperative determination of resectability plays a critical role in the decision to proceed with pelvic exenteration. In 25–30% of candidates for exenteration, unresectable or disseminated disease is found at operation [41]. An extremely careful examination of the opened abdomen is mandatory before proceeding, with particular attention to the liver and the periaortic and renal lymph node–bearing areas. The use of intraoperative liver ultrasound may be necessary. The rest of the examination consists of a systematic palpatory assessment of the remaining viscera. Particular attention is paid to the peritoneum and omentum. An adequate examination requires that the small intestine be delivered from the pelvic cavity. The only categorical contraindication to resection at this point is tumor extension out of the true pelvis. The obturator fossa and lateral pelvic wall are palpated to determine whether the tumor extends beyond the psoas muscle. In some circumstances, such as with a sarcoma, resection and reconstruction of the involved external iliac vessels may be justified [42]. Major vessel invasion by squamous cell carcinoma and adenocarcinoma is regarded as a contraindication to exenteration because cures are rare.

The next step in assessing resectability is to open the peritoneum from the sacral promontory along the brim of the pelvis to the bladder. This is important because tumor fixation in the pelvis cannot be accurately ascertained in the presence of an intact pelvic peritoneum. This exploratory maneuver is performed first on the side where the tumor is closest to the pelvic side wall as determined preoperatively by CT scan and pelvic examination. Another exploratory maneuver that is often helpful in defining tumor extent is mobilization of the urinary bladder from the retropubic region. Also, mobilization of the rectum from the anterior surface of the sacrum provides a bloodless assessment of the depth of the posterior and anterior portions of the pelvic cavity. These actions permit better assessment of the mobility and lateral extent of the tumor and may allow determination that the lesion is unresectable before transsection of the ureter, colon, and visceral blood supply.

After examination has been completed and exenteration is to be performed, the use of a multiblade, self-retaining retractor provides excellent exposure. At this point, the sigmoid colon is divided to maintain the specimen at the center of the pelvis. In operations for rectal cancer, the inferior mesentery artery is divided at its origin to ensure an adequate lymphadenectomy. The small intestines and the stapled proximal end of the divided descending colon are covered by the omentum and retracted with moist towels into the upper abdomen. The cecum is partly mobilized and held cephalad with the folded edge of a laparotomy gauze and under another blade of the self-retaining retractor. Slight Trendelenberg position should be obtained before the intestinal packing is performed. A word of caution about excessive packing of the abdominal viscera: If packing results in an abnormally elevated diaphragm with occlusion of the hepatic veins or inferior vena cava that impair the blood flow, outflow hypotension will result. Careful repositioning of packs and retractors are then necessary to avoid hypotension.

When the posterior rectal wall is not involved by the pelvic malignancy, blunt dissection to the tip of the patient's coccyx is permissible. However, sharp dissection under direct vision of the entire rectal mesentery is preferable and is essential for large rectal cancers. With suspicion of posterior extension of rectal cancer, the presacral dissection should be done under direct vision. Before the surgeon proceeds with the lateral dissection in patients with rectal tumors, the mesorectum should be divided by a sharp dissection that avoids blunt maneuvers that may leave residual disease or perforate the tumor-bearing rectal segment. Tumor extension to the coccyx or sacrum is not necessarily a contraindication to an exenterative procedure, provided that the appropriate resection is executed. Thus, extreme caution must be exercised to avoid entering a tumor-involved sacrorectal space. A clear concept of anatomy for this situation is necessary to perform required dissection.

The approach to the lateral pelvic dissection depends partly on the type of exenteration planned because the use of a specific combination of dissections is determined by the extent of the neoplasm. Several variations of pelvic exenteration have been recently summarized [43]. The parietal layer of the endopelvic fascia is first divided medial to the genital femoral nerve, thereby preserving the nerve. There are no lymph nodes lateral to this nerve, which lies over the psoas muscle. The parietal fascia is then reflected medially. The fascia is contiguous with the vascular sheath of the common and external iliac vessels. This sheath is dissected off these vessels. The testicular or ovarian vessels and round ligament in females are identified, clamped, transsected, and ligated. Because the dissection is identical on both sides of the pelvis, the procedure provides an excellent teaching opportunity to demonstrate the dissection on one side and assist a senior trainee or junior faculty member on the other. The attending surgeon clearly should perform on the side of the pelvis where tumor extension is greatest. Division of the ureter is usually delayed until the surgeon is certain that a complete exenteration will be performed. Maintaining the ureter intact allows continuous measurement of urinary output and avoids leakage of urine into the operative field. This is particularly important when

the urine is infected. The ureters are always ligated distally when they are divided.

After the pelvic fascia has been reflected from the psoas and major vessels, the fascia is reflected from the obturator internus muscle. At this point, the obturator nerve can be seen through an opening adjacent to this fascia. To preserve the nerve, the pelvic fascia is incised over it, and the nerve is reflected laterally. It is then protected laterally with a vein retractor until all pelvic fascia and associated lymph nodes have been reflected away from the obturator internus to the origin of the levator ani. The levator ani originates from the fascia of the obturator internus. The visceral branches of the internal iliac vessels are then systematically ligated and divided. It is not necessary to ligate the hypogastric vessels unless they are involved by tumor. If this is done, care must be taken to avoid the superior gluteal artery that originates on the deep or lateral surface of the internal iliac artery near its origin. This is especially important if the operation is associated with a hemipelvectomy because the blood supply to the posteriorly based flap may be compromised.

The suspensory bladder attachments are transsected at this point. The peritoneal incision that was made lateral to the external iliac vessels and medial to the genitofemoral nerve is extended toward the internal abdominal ring onto the lower edge of the midline abdominal incision. The areolar tissue in the prevesical space is dissected away from the pelvic side of the pubis adjacent to the pubic periosteum. Entry into the retropubic vascular perivesical space is to be avoided because troublesome bleeding may occur and it is difficult to control. This portion of the operation is generally best performed from the perineal approach. The lymphatic cord passing from the thigh into the pelvis can then be identified; this is composed of fatty, areolar tissue containing the major lymphatics connecting the iliac and femoral lymphatics. It is ligated adjacent to the inguinopectineal triangle to prevent lymph fistulas and lymphoceles from the large volume of fluid that generally flows from the lower extremities into the pelvic space.

The rest of the lateral pelvic dissection depends on the condition of the perivenous tissues and identification of the lumbosacral plexus. This nerve plexus, composed of the fourth and fifth lumbar nerve roots, is situated dorsally and laterally from the obturator nerve, lying adjacent to the caudal fibers of the obturator internus muscle. After identification, the other sacral roots should be avoided by continuing the dissection medially and downward.

After the remaining vascular structures have been transsected, the extent of the dissection along the pelvic surface of the levator ani muscle is determined by assessment of the lateral extent of the neoplasm. The levator ani originates from the fascia of the obturator internus muscle. When the levator ani has been circumferentially

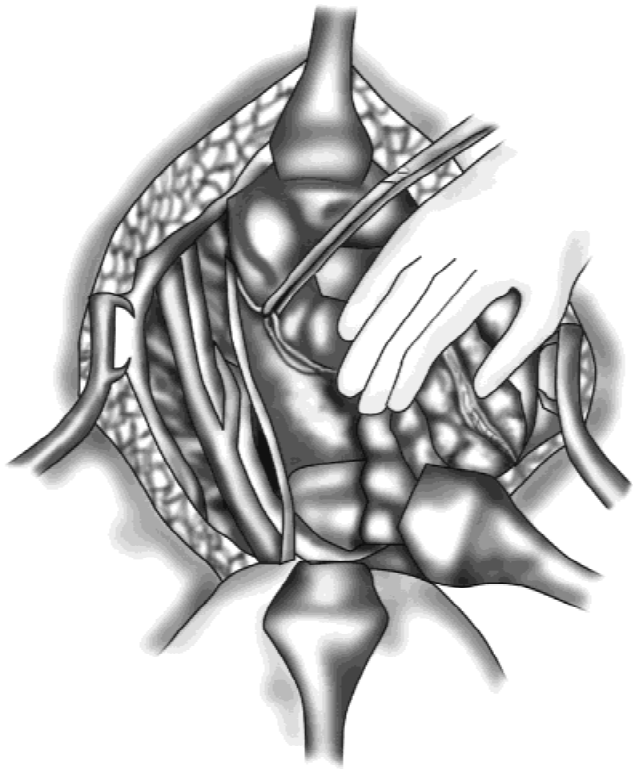

Fig. 1. Appearance of the pelvis after completion of the lateral dissection. The dissection has been performed between the parietal layer of the endopelvic fascia and the pelvic parietes. The branches of the internal iliac artery and vein have been divided and suture ligated or clipped. The obturator nerve has been preserved [37].

demonstrated, the rectum mobilized to the coccyx, and the bladder mobilized to the periurethral region, the perineal dissection can begin (Fig. 1).

The perineal incision in men extends from the base of the scrotum to the coccygeal region. In women, the amount of skin sacrificed is determined by the type and the proximity of the neoplasm. In some instances, it is necessary to resect the entire vulva, whereas in most cases of carcinoma arising away from the labia, the incision can be made along the labia minor, thereby preserving the major labia for reconstruction.

In men, the proximal end of the penile urethra is exposed, and the urethra is ligated and divided. In operations for vesical carcinoma, the entire urethra may be dissected from the penis through a ventral incision as prophylaxis against later urethral cancers. In women, the urethra is removed en bloc with the specimen. After the subcutaneous tissues are divided, the ischial rectal space is identified, and the fascia is incised medial to the ischium. The contents at the ischiorectal space are then reflected from the vascular plane on the medial side of the ischium. The caudal surface of the levator ani is identified as the medial and cephalad roof of the ischiorectal space. For tumors not associated with the posterior rectal wall, it is preferable that the pelvis is entered pos-

teriorly. However, dividing the levator ani with electrocautery avoids significant bleeding. Finally, the retropubic periosteal insertions are divided, and the specimen is removed through the perineum. At this point, most of the bleeding will be associated with the retropubic space and with the lateral portions of the cut ends of the levator ani. These are ligated or cauterized. After the empty pelvic cavity has been meticulously checked for hemostasis, the entire area is irrigated with copious amounts of warm saline solution.

STOMAS AND ANASTOMOSIS

Complete exenterations require ureterointestinal anastomoses, ileostomy, colostomy, and intestinal anastomoses. The techniques for these procedures are standard for many operations. The site for stomal placement is best determined by an enterostomal therapist who will simultaneously educate the patient. Sites need to be conveniently accessible to the patient and not be in skin creases that shift with patient position. The skin surface above the stomal site must be flat enough to permit firm adherence of the ostomy device. The stomas should not be too near previous scars or boney prominences or in a site that has been or will be irradiated. The end of the intestine must extend far enough above the skin site to allow eversion of the end to form a nipple the diameter of the stomal device. No tension or fascial stricture on the intestine traversing the abdominal wall should exist. If there is any question as to whether the intestine to be used for the stoma has been irradiated, there should be a frozen-section examination of the anticipated stomal end. Radiation in excess of the amount compatible with safe wound healing characteristically produces sclerosis of the microvasculature identifiable microscopically. If sclerosis is present, intestine free of these findings must be used. The same consideration applies to the ureter to be anastomosed to intestinal conduits. When situations exist that may necessitate compromise to these considerations, healing may still occur, but a longer time for healing is required, and either proximal temporarily decompressing colostomies or ureteral catheters as stints may be required.

The vascular anatomy of both the intestines and the ureter is critical for both stomas and anastomoses. The intestine is supplied by end arteries from its mesentery, and intramural vasculature will not sustain intestinal survival much beyond a centimeter from the entry point of the nearest end artery. The best test is to see whether the intestinal end bleeds.

The ureteral vasculature is carried in its adventitia. If the adventitia is stripped away, the ureter will be devascularized. Thus, with ureteral mobilization and anastomosis, adventitia must remain in place to the point of anastomosis.

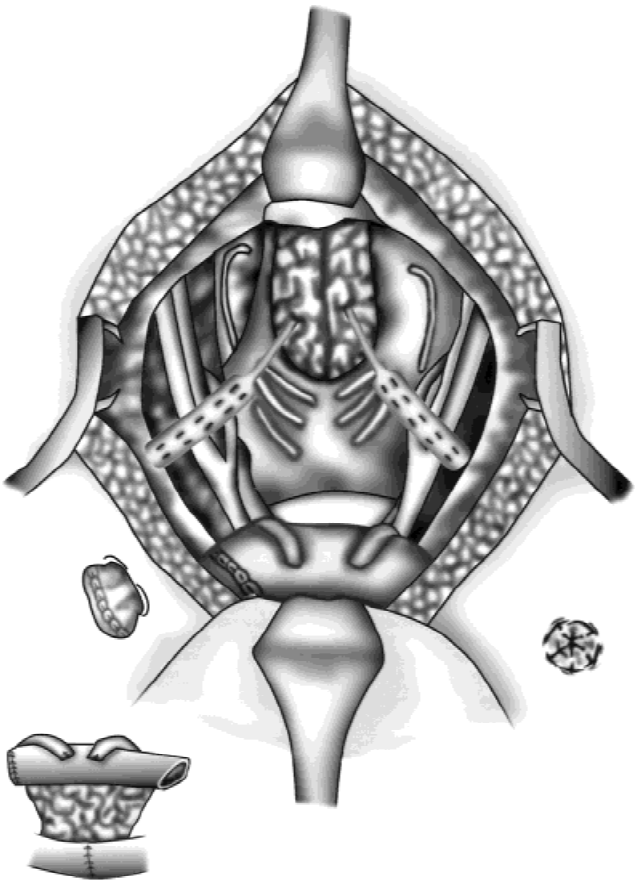

Fig. 2. After hemostasis is obtained, closed suction drains are placed into the perineum. The drains exit through drain incisions in the perineum medial to, but not over, the ischium [37].

Before the abdomen is closed, all openings in the mesentery and left gutter should be sutured to reduce the risk of delayed internal hernias.

The perineal wound is closed in two layers, and two closed suction drains are placed in the posterior pelvic cavity and brought through separate incisions lateral to the perineal closure, not overlying the ischium (Fig. 2). The colostomy is then created in the usual manner. For urinary diversion, we prefer the ilial conduit described by Bricker [6] (Fig. 2). Other urinary diversion methods are available, and their use depends on the surgeon's experience and personal preference [44,45].

The empty pelvis is frequently the source of considerable morbidity, especially in patients who have had radiation therapy. There are several procedures designed to fill most of the pelvic cavity. The most simple, but not often available, is a large omental pedicle flap based on the gastroepiploic vessels and is transposed through the lateral gutter on the right side after the cecum and ascending colon are mobilized. Often, the thickness and length of the omental tissue will fill most of the inner pelvis. Other methods that can be used include placement

TABLE II. Morbidity and Mortality Rates in 11 Series of Pelvic Exenterations

Reference	Years of review	No. of patients	Morbidity rate	Mortality rate
Brunschwig [1]	1947–1950	100	—	20%
Brunschwig [1]	1962–1965	112	—	12%
Kiselow et al. [11]	1950–1965	207	44%	10%
Symmonds et al. [48]	1950–1971	198	—	8%
Rutledge and Burns [49]	1955–1976	296	—	13%
Boey et al. [41]	1964–1981	49	50%	18%
Jakowatz et al. [50]	1956–1984	104	49%	8%
Roberts et al. [51]	1978–1985	38	45%	5%
Soper et al. [52]	1970–1987	69	46%	7%
Pearlman [47]	1980–1992	77	38%	5%
Lopez and Monafo [16]	1940–1990	232	45%	14%

of absorbable or permanent mesh at the pelvic inlet, pedicle myocutaneous flaps, or free flaps using microvascular reconstruction [46].

COMPLICATIONS OF PELVIC EXENTERATION

Many complications of this procedure and its modifications are representative of those associated with any major cancer operation. They are related to fluid and blood transfusion requirements, in which large volumes of crystalloid solutions are generally necessary. Over the years blood loss has been minimized, and the transfusion requirements for patients with normal hemoglobin levels preoperatively now are minimal. Monitoring of central venous or pulmonary wedge pressure is part of the perioperative care in these patients who are routinely placed in an intensive care unit setting for the first 48–72 h postoperatively. There is continued extracellular fluid loss into the operative area through the denuded pelvis. Thus, the closed suction drain system will drain 250–1,000 ml/day on average.

The complications with pelvic exenteration were the subject of a comprehensive 1967 publication [11]. They have been detailed in many previous publications [7,8,13–18]. More recently, Pearlman [47] reviewed the subject of complications after pelvic exenteration in great detail. The complication rate has varied between 30% and 70% including nonspecific intraoperative or postoperative problems such as myocardial infarction, arrhythmia, pneumonia, and postoperative bleeding. Prevention of these complications is possible, to some extent, with proper patient selection and surgical technique, but there are unavoidable risks involved with any extensive surgery. Table II shows major operative morbidity and mortality in 11 selected series [1,11,16,41,47–52]. Most of the literature on total pelvic exenteration implies that morbidity due to the procedure is only an immediate postoperative phenomenon. There is little information on the long-term consequences of the operation. Our experience has shown that morbidity from this operation continues. In a 50-year experience at EFSCH, 11 patients died of complications of surgery several years after the operation [17]. The most important causes of long-term morbidity were stenosis of the ureterointestinal anastomosis causing hydronephrosis and, not infrequently, renal failure. In addition, obstruction of the irradiated small intestine in the pelvis is notoriously difficult to manage and often produces fistulas. Reoperation may damage friable intestine and result in small bowel resections, which increase malabsorption and malnutrition. Because of the long-lasting changes associated with total pelvic exenteration, careful follow-up of patients is mandatory and should include monitoring of renal function, nutritional status, and stomal integrity. Episodes of partial small bowel obstruction are not uncommon and must be treated promptly but conservatively. Although Table III shows an older series of patients reported in 1967, this series is the only reliable, available data on late (after hospital discharge) complications of pelvic exenteration [11]. Table IV shows the mortality experienced in a 50-year review of 232 patients who underwent total pelvic exenteration at EFSCH, and Table V shows the nonfatal complications in 105 (45%) of 232 patients [17].

The wound complication rate in pelvic exenteration is 3–20%. This wide range reflects differences in defining complications including sepsis. Although theoretically preventable, wound infection can be minimized by leaving the skin and subcutaneous tissue partly open and leaving a wound pack that can be easily removed between staples or sutures on postoperative day 5. The presence of two stomas, the length of operation, and the unavoidable contamination from the urinary tract and gastrointestinal system makes wound sepsis a frequent occurrence. Delayed primary closure can also be successful if the wound remains clean 3–4 days postoperatively. Problems arising from urinary diversion occur in 9–25% of patients [47]. They include anastomotic and stomal complications and long-term stricture formation at the

TABLE III. Complications in 75 of 191 Women Who Left the Hospital after Pelvic Exenteration for Carcinoma of the Cervix*

Complication	No. of patients
Intestinal obstruction	
Operation (10), tube only (2)	12
Progressive hydronephrosis requiring ileal bladder revision	3
Enteroperineal fistula	
Recurrent carcinoma (2), without recurrent carcinoma (7)	9
Rectoperineal fistula	
Recurrent carcinoma (1), without recurrent carcinoma (4)	5
Pyelonephritis	12
Ileal stoma revision	14
Colostomy revision	16
Perineal sinus or abscess	7
Perineal hernia	4
Renal calculus	2
Serum hepatitis	1
Thrombophlebitis	1
Incisional hernia	1
Osteitis pubis	1
Total	88

*Reproduced with permission from Lippincott-Raven, Kiselow M. et al. [11].

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TABLE V. Principal Nonfatal Complications in 105 of 232 Pelvic Exenterations

Complication	No. of complications (%)
Intestinal obstruction	14 (8.2)
Abdominal wound sepsis	52 (30.6)
Perineal wound sepsis	26 (15.3)
Fecal or urinary fistula	33 (19.4)
Stoma problems	24 (14.1)
Other	21 (12.4)
Total	170 (100)

ureteroileal anastomosis. Detailed analysis of complication rates related to the various forms of urinary diversion is beyond the scope of this article, and the reader is referred to excellent work reported by others [45–47].

LONG-TERM RESULTS OF PELVIC EXENTERATION

Except in highly selected cases in which palliative pelvic exenteration has a role, the long-term goal of this operation is to cure locally advanced neoplasms arising in the pelvis. As such, recurrence-free survival should be the long-term end point. In addition, quality-of-life assessment should be part of every study on ultraradical pelvic surgery [19]. About 10% of patients with rectal cancer present with locally advanced disease incurable by conventional operations. The therapeutic value of exenterative surgery has been amply documented.

In carcinoma of the rectum, the 5-year survival rate is clearly discernible from the literature, but the recurrence rate and patterns of failure are difficult to define. Table VI presents 5 series totaling 205 patients subjected to pelvic exenteration for rectal cancer [14,41,49,53]. In 177 patients (86%), the operation was the primary form of treatment. In 28 patients, exenteration was performed for recurrent disease. The overall recurrence rate differed from 26% to 57%, with an average of 42%. In these series, the 5-year survival rate ranged from 31% to 56%, averaging 44% at 5 years. The most common sites of recurrences are the pelvis, perineum, lung, and liver [47,53].

The pioneering studies of Spratt and associates have provided significant information on the biological behavior of locally advanced colorectal cancer. The recurrence rates after radical surgery depend not only on local extent of the disease but also on its ability to metastasize to the regional lymph nodes. Thus, it is not surprising that in our series of 58 patients undergoing multivisceral resections for cure, the recurrence rate for patients with Dukes B (T3–4, N-0) tumors was 24% compared with 100% for patients with lymph node metastases [8,16]. Because locally advanced rectal cancer is most often approached surgically with a conventional procedure (abdominoperineal or low anterior resection), a significant proportion of pelvic exenterations for rectal cancer are performed for postsurgical recurrence. The long-term results of radical pelvic surgery for recurrent disease are substantially poorer than for patients who have not had previous operations. In the series of Hafner et al. [53], for example, the recurrence rate was 34% in patients with primary disease and 66% in patients having surgery for recurrent rectal carcinoma. The overall 5-year survival rate was 43% in patients with primary tumors compared with 20% in those with recurrent lesions. Several series, including our own, have reported similar results [14,38,54,55].

Current data support the role of preoperative chemoradiation for rectal cancers with transmural invasion. An extensive deliberation of this subject is beyond the scope of this review. However, preoperative radiotherapy re-

TABLE VI. Recurrence and Survival After Pelvic Exenteration for Rectal Cancer in 5 Series

Reference	No. of patients	Primary	Recurrent	Recurrence rate	5-year survival rate
Hafner et al. [53]	68	47	21	44%	31%
Boey et al. [41]	49	49	0	57%	38%
Eckhauser et al. [55]	12	12	0	48%	50%
Lopez et al. [14]	27	20	7	26%	56%

portedly converts to resectability some rectosigmoid carcinomas that were originally deemed unresectable, usually because of fixation to the pelvic wall [57–59]. With evidence of down-staging by radiotherapy, now used more frequently in conjunction with chemotherapy, patients with locally advanced rectosigmoid carcinoma should be considered for preoperative treatment with this adjuvant. Patients with advanced central pelvic disease with bladder or vaginal penetration may not need the preoperative adjuvant therapy. Under such circumstances, preoperative treatment does not change the magnitude of the operation. Also, some apparent adherence to the lateral pelvic wall will be due to inflammation and not to cancer.

Carcinoma of the cervix treated by pelvic exenteration generally follows failure of nonoperative therapy. Accordingly, the need for exenterative surgery is largely confined to treatment of central pelvic recurrence. The vast cumulative experience with pelvic exenteration was gained primarily from treating patients who had postirradiation recurrent disease [1,7,17,60,61]. Table VII shows survival after pelvic exenteration for cervical carcinoma in several selected series, representing experience gained over several decades in >1,000 patients [54,56–58,60,66–68]. The overall 5-year survival rate ranged from 23% to 61% and averaged 42%. Carefully selected patients undergoing partial exenteration have a higher survival rate because of smaller lesions that permit a less extensive resection [62]. In general, many series have not analyzed subgroups into risk factors. One exception is the experience of Shingleton et al. [63] who divided their patients into three risk groups. The low-risk group had tumors <3 cm, no fixation to the pelvic wall, and a disease-free interval after radiotherapy of at least 1 year. The high-risk group had large tumor masses with pelvic wall tethering and a short disease-free interval. The intermediate group had a combination of these factors. The 5-year survival rates were 58%, 50%, and 42%, respectively. The morbidity rate of pelvic exenteration is not significantly different in patients with cervical carcinoma compared with rectal or other primary tumors. Previous irradiation increases the rate of complications after exenteration. In a contrary position, Moffat et al. [64] indicated that in previously irradiated patients the operative blood loss, transfusion requirements, and operative time are reduced.

TABLE VII. Survival After Pelvic Exenteration for Cervical Carcinoma in Selected Series

Reference	No. of patients	Survival percentage[a]
Averette et al. [60]	92	58
Lawhead et al. [67]	65	23
Morley et al. [68]	100	61
Soper et al. [52]	69	40
Lopez [66]	155	37
Rutledge and Burns [49]	296	42

[a]Five-year survival rates.

Total exenteration for other pelvic primary tumors represents a minority and largely anecdotal experience. Such tumors often are treated by lesser operations or modified exenterations [43]. Nevertheless, selected patients are candidates for extensive vulvar, vaginal, or endometrial carcinomas that are confined to the pelvis. The morbidity and mortality of the operation are no different than those for the more common indications, and long-term survivors have been reported. It must be emphasized that modern treatment of certain pelvic cancers is based initially on nonoperative therapy that is frequently successful, a prime example of which is anal carcinoma [65].

SUMMARY

Pelvic exenteration is an established procedure in the armamentarium of the oncologic surgeon. The patient selection process, operative details, morbidity and mortality, and long-term results have been addressed in a comprehensive review [66]. The quality of life is markedly affected by this operation. Critical to success in this field is the multidisciplinary approach to preoperative treatment, pre- and postoperative care, nursing support, and attentive follow-up, all in a setting that combines surgical expertise and extreme compassion. There is clear evidence that both morbidity and mortality have recently declined as experience has been gained and technologic advances have improved. The operation is most frequently indicated for radiation failures in the treatment of gynecological malignancies. It is also justified for complications of nonoperative therapy, such as pelvic radionecrosis, and in the occasional patient who can be effectively palliated but not cured. For carcinoma of the rectum, it is indicated as primary treatment of advanced lesions that penetrate into the lumen of adjacent viscera.

All other patients should be considered for chemoradiation preoperatively. Reoperation for recurrent rectal carcinoma following abdominoperineal or low anterior resection is rarely successful and often requires sacrificing portions of the bony pelvis. This is best avoided by a well planned and adequate standard first operation. Whenever there is doubt that en bloc resection can be done primarily, a surgeon with experience with pelvic exenterative should be consulted. In the modern realm of multidisciplinary cancer treatment, exenterative pelvic surgery still has a place, provided the quality of life is preserved to the greatest extent possible.

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